Review Article

Deltoid Ligament Rupture in Ankle Fracture: Diagnosis and Management

Abstract

The last stage of a supination-external rotation ankle fracture involves either transverse fracture of the medial malleolus or rupture of the deltoid ligament. When the deltoid ligament ruptures, a “bimalleolar equivalent” ankle fracture occurs, and the surgeon is presented with several diagnostic and therapeutic challenges. In the native ankle, the deltoid ligament provides restraint to eversion and external rotation of the talus on the tibia. In bimalleolar equivalent ankle fractures, there is often gross medial instability even after fibular reduction. Retraction of the deltoid with subsequent healing in a nonanatomic position theoretically may cause instability, persistent medial gutter pain, and loss of function with risk of early arthritis. In mild cases, deltoid injury may not be obvious, and potential diagnostic techniques include preoperative and intraoperative stress radiography, MRI, and ultrasonography. The most common injury pattern is avulsion from the medial malleolus, and most current repair techniques involve direct repair of the capsular and deltoid injuries involving suture anchors in the medial malleolus and imbrication of the superficial and deep deltoid fibers. To date, there is limited evidence of superior clinical outcomes with the addition of deltoid repair compared with open reduction and internal fixation of the fibula alone.

Most rotational injuries about the ankle fit the supination-external rotation (SER) model of the landmark 1950 study by Lauge-Hansen. According to this model, with the foot supinated, external rotation of the talus on the tibia produces (1) rupture of the anterior-inferior tibiofibular ligament, (2) oblique fracture of the lateral malleolus, (3) rupture of the posterior-inferior tibiofibular ligament (or posterior malleolar fracture), and (4) either transverse fracture of the medial malleolus or rupture of the deltoid ligament. When the medial malleolus fractures before the deltoid ligament ruptures, the injury is called a bimalleolar ankle fracture, and open reduction and internal fixation (ORIF) of both malleoli is indicated to restore stability to the mortise. However, when the deltoid ruptures and the medial malleolus remains intact, the injury is termed a bimalleolar equivalent ankle fracture, indicating that although the medial malleolus remains intact, the ruptured deltoid ligament renders the ankle functionally unstable. ORIF of the fibula is recommended in these cases, and the syndesmosis is typically repaired with syndesmotic fixation if unstable. However, controversy remains regarding the assessment of deltoid integrity and long-term consequences of deltoid repair.

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The tibiotalar joint has been described as a mortise and tenon joint because of its similarity to the woodworking joint of the same name. The medial, lateral, and posterior malleoli, together with their supporting ligaments and the contours of the tibial plafond and talar dome, stabilize the talus under the tibia.3,4 The syndesmotic ligaments stabilize the fibula within the incisura. On the lateral side, the anterior and posterior talofibular ligaments and the calcaneofibular ligament provide restraint to talar inversion and anterior/posterior talar translation. On the medial side, the deltoid complex stabilizes the talus against the medial malleolus.

The deltoid complex is a large, fan-like structure that originates from the medial malleolus and inserts broadly onto the talus, calcaneus, and navicular5 (Figure 1). The deltoid can be divided into two ligaments based on its insertion sites. First, the superficial ligament originates primarily from the anterior malleolus of the medial malleolus, fanning out to include the superficial posterior tibiotalar, tibiospring, and tibionaviccular ligaments (Figure 1, A). Second, the deep ligament is confluent with the tibiotalar joint capsule and inserts onto the medial aspect of the talus as the deep anterior tibiotalar ligament (originating from the anterior malleolus just deep to the tibionavicular and tibiospring ligaments) and deep posterior tibiotalar ligament (originating from the posterior malleolus and intercollicular groove) (Figure 1, B).

The deltoid ligament is critical in the normal biomechanics of the ankle, serving as the tether of the talus to the medial malleolus to guide the talus through normal physiologic motion.6-8 The superficial deltoid is understood to be the primary restraint to hindfoot eversion, whereas the deep deltoid is understood to be the primary restraint to talar external rotation.7 Valgus tilting of the talus within an intact mortise requires complete ruptures of both the deep and superficial ligaments.6,9

Pathoanatomy and Pathomechanics

In the Lauge-Hansen1-2 model of SER injury, the deltoid is ruptured secondary to external rotation force. Either the superficial or the deep deltoid ligament can rupture as an avulsion from the medial malleolus (majority), as an avulsion from the distal insertion (minority), or as a midsubstance tear (least common).10-12 Ruptures are most commonly of both the superficial and deep portions but can also be isolated to either portion alone.

Michelson et al13 conducted a cadaver study of different stages of SER ankle injuries in which they transected ligaments and/or made bony osteotomies to simulate fractures and then subjected the cadaver specimens to axial loading through physiologic motions. These authors demonstrated that the talus continues to move in a physiologic manner following SER stages I-III, presumably because the deltoid functions as an effective medial tether, stabilizing the talus sufficiently to guide its motion. It is only when the deltoid ligament is rendered incompetent (SER stage IV) that talar motion becomes abnormal.

In another important cadaver study, Ramsey and Hamilton14 demonstrated the implications of small changes in tibiotalar alignment. These authors showed that even a 1-mm lateral deviation of the talus on the tibia results in a 42% reduction in the tibiotalar contact area. This phenomenon represents a dramatic alteration in joint kinematics that has the potential to lead to abnormal cartilage wear and degenerative change.

Diagnostic Techniques

Distinguishing bimalleolar equivalent ankle fractures from isolated lateral malleolar fractures is critical because isolated lateral malleolar fractures can generally be managed nonsurgically, whereas lateral malleolar fractures associated with deltoid incompetence constitute unstable injuries requiring...
ORIF in most patients. The available methods of testing for rupture of the deltoid ligament are reviewed here.

**Physical Examination**

Swelling, ecchymosis, and medial tenderness are physical examination findings that have been advocated for use in determining whether there is injury to the deltoid ligament in the setting of a lateral malleolar fracture with a normal medial clear space. Using stress radiography (discussed later) as the benchmark, McConnell et al. determined that each of these physical exam modalities had little utility in detecting deltoid injury. DeAngelis et al. reported similar results.

**Plain Radiography**

Examination of the medial clear space on a static (unstressed) mortise radiograph view is another method that has been advocated for identifying deltoid ligament ruptures. On neutral or dorsiflexion mortise views, a wide medial clear space is defined as ≥4 mm and at least 1 mm more than the superior tibiotalar joint space. Ankle with a fibula fracture and a wide medial clear space are generally considered to have deltoid disruption requiring surgical treatment. Notably, a normal medial clear space is likely not sufficient to exclude deltoid ligament injury because a subset of ankles with a normal static medial clear space will have widening with external rotation stress (discussed later). Of note, in an interesting study, Nwosu et al. described the “medial malleolus fleck sign,” thought to represent a small avulsion of bone from the medial malleolus in bimalleolar equivalent ankle fractures.

**Stress Radiography**

The benchmark for preoperative evaluation of deltoid ligament integrity has become the external rotation stress test. Park et al. took radiographs of six fresh cadaver ankles with simulated SER ankle fractures and found that a medial clear space of ≥5 mm with manual dorsiflexion and external rotation was a reliable predictor of deep deltoid ligament status. Michelson et al. conducted a similar study with respect to gravity stress views (where the patient lies in the lateral position and gravity is allowed to induce an external rotation and lateral translation stress) and demonstrated similar results.

Of note, some have speculated that if the mortise is stable to weight bearing, there is adequate stability to the mortise and that stress or gravity stress images are not necessary. However, congruent weight bearing does not maximally stress the syndesmosis because the vast majority of weight passes directly from the talus to the tibial plafond regardless of the presence of the fibular lateral buttress. On the basis of the current literature, stress or gravity stress films appear to be superior to simple weight-bearing films for evaluation of syndesmotic integrity.

One algorithm is to perform either gravity or manual external rotation stress testing on all patients with a Weber B fibula fracture and a normal medial clear space. Manual external rotation testing consists of a patient lying supine with the ankle internally rotated by 10° to obtain a mortise view of the ankle in neutral dorsiflexion. The tibia is stabilized and an external rotation force is applied to the foot. Gravity stress testing is achieved by having the patient lie in the lateral decubitus position with the injured extremity down such that the weight of the foot induces an external rotation and lateral translation stress. For both manual and gravity tests, the medial clear space is considered to have widened if it is >4 and >1 mm greater than the superior tibiotalar joint space.

**Magnetic Resonance Imaging**

Nortunen et al. identified 61 patients with isolated lateral malleolar fractures resulting from SER mechanisms. Patients were evaluated with a manual external rotation stress test, and the anterior and posterior portions of the deep deltoid ligament were investigated using MRI. The authors found that all 61 patients had injuries to the deltoid ligament on MRI. These were typically just partial tears or edema; complete tears were rare, even among patients who had positive stress tests. There was a high degree of variability of medial clear space in patients with similar MRI findings, and the interrater reliability of MRI findings was much lower than the interrater reliability of stress test findings. On the basis of these results, the authors recommended against use of MRI in choosing between surgical and nonsurgical management of SER fractures.

Of note, one group used MRI to evaluate the ability of the Lauge-Hansen classification system to predict ligament injuries in ankle fractures. They found that the Lauge-Hansen system correctly predicted ligamentous injuries in 94% of cases.

**Surgical Management**

**Surgical Sequence**

Surgical management of bimalleolar equivalent ankle fractures typically begins with ORIF of the fibula through a lateral or posterolateral approach. The deltoid ligament or posterior tibial tendon can become impinged between the talus and medial malleolus, preventing closure of the medial clear space and/or reduction of the fibula. In these cases, clearance of the medial gutter through a separate medial incision is recommended. After the fibula has been fixed, the syndesmosis should be evaluated using the Cotton test, in
which a lateral distracting force is applied to the fibula and the syndesmosis is evaluated for dynamic widening on the mortise view.\textsuperscript{25,26} If the syndesmosis widens on Cotton test, the syndesmosis should be reduced and transsyndesmotic fixation should be placed. For many surgeons, the operation is considered complete at this point; however, for others, the final step in the procedure consists of evaluation for deltoid incompetence and/or potential performance of deltoid ligament repair.

**Indication for Deltoid Ligament Repair**

Even among those advocating deltoid ligament repair, it remains controversial in which patients deltoid repair should be performed. One argument is that deltoid repair should be performed in all patients with bimalleolar equivalent ankle fractures. The rationale is that if the deltoid was incompetent enough to consider the fracture unstable, the deltoid should be repaired to restore the medial tether and optimize tibiotalar kinematics. Other surgeons repair the deltoid only if medial-sided exposure is already required to clear soft tissue from the medial gutter. One group advocates deltoid ligament repair among high-level athletes and only after arthroscopic confirmation of complete deltoid ligament rupture.\textsuperscript{27} Others have used intraoperative stress radiography to evaluate for persistent medial-sided instability at the end of the case, indicating repair only among those who are intraoperatively unstable after ORIF.\textsuperscript{12} Intraoperative stress testing can be in the form of external rotation and talus tilt stress\textsuperscript{12} or syndesmotic distraction using a transfibular tap.\textsuperscript{28}

One algorithm is to perform intraoperative stress radiography after the fibular (and, if indicated by the Cotton test, syndesmotic) ORIF.\textsuperscript{12} An external rotation stress is applied on the mortise view, and the medial clear space is evaluated for widening of $>4$ and $>1$ mm greater than the superior tibiotalar clear space. Patients who meet both of these parameters are considered to have a positive intraoperative external rotation stress test. Importantly, this is supplemented with an eversion stress test in which an eversion stress is applied and the talus is evaluated for tilt (which evidence suggests indicates a complete rupture of both the deep and superficial deltoid ligaments\textsuperscript{6,9})(Figure 2). This eversion stress test functions similarly to the lateral talar tilt test used in patients with potential lateral ligament instability. Corresponding to talus tilt with eversion stress, one also observes increases in the distances between the tip of the medial malleolus and the distal-medial radiographic projections of the talus.

\textbf{Figure 2}

Intraoperative fluoroscopic images showing the eversion stress test. \textbf{A}, Unstressed ankle after fibular and syndesmotic open reduction and internal fixation (ORIF). \textbf{B}, Eversion-stressed ankle after fibular and syndesmotic ORIF showing 9° of talar eversion. \textbf{C}, Unstressed ankle after fibular ORIF. \textbf{D}, Eversion-stressed ankle after fibular ORIF showing 7° of talar eversion. \textbf{A–D}, Along with talar eversion, one observes corresponding increases in the distances between the tip of the medial malleolus and the distal-medial radiographic projections of the talus.
occurred. The handful of cases for which intraoperative stress films were available postoperatively were retrospectively reviewed. It was found that the cutoff for fixing the deltoid had generally been about $7/\sqrt{176}$; hence, this was adopted as the threshold. Little work has been done in the literature to establish a threshold value for such a measurement; establishing this threshold should be an area for future research. Widespread adoption of any specific threshold should not be encouraged until studies have born such a threshold out.

Of note, after anatomic reduction of the fibula and syndesmosis (if necessary), meaningful lateral talus translation does not occur. Fibular and syndesmotic fixation appear not to allow for widening medially unless the syndesmosis or fibula was malreduced or fixation was inadequate. However, meaningful talar tilt, nevertheless, occurs in about half of these patients. In patients with positive intraoperative stress radiographs, deltoid repair is indicated and performed.

## Technique for Deltoid Repair

Techniques for deltoid ligament repair in ankle fracture have been described by several different groups (Table 1), although the techniques have not been compared with each other.\textsuperscript{11,12,27,29,30} All recent descriptions have in common the anchoring of suture to the distal-medial tibia with anatomic repair of the deltoid fibers to the medial malleolus. The authors vary in the location of their skin incision, whether they incorporate the superficial versus deep deltoid fibers, how they address avulsion from the calcaneus, the number and position of suture anchors, and the inclusion of anchor-to-post or anchor-to-button reinforcement.

Deltoid repair is performed as follows. A 5-cm curvilinear incision is made midline over the medial malleolus, and the corresponding skin flaps are mobilized to facilitate

### Table 1

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year of Publication</th>
<th>Technique Summary</th>
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<tbody>
<tr>
<td>Lack et al\textsuperscript{11}</td>
<td>2012</td>
<td>A suture anchor is placed in the talus to secure suture running up within the intercollicular groove to a screw in the distal-medial tibial metaphysis, creating an anchor-to-post reinforcement of the subsequent repair. The sutures are then continued from the tibial screw down to the superficial and deep deltoid fibers in a fan-like fashion. Alternatively, if the deep ligament is avulsed from its insertion on the talus, two sutures from the talar suture anchor are used to repair the deep ligament to the talus; all four sutures (including the two from the knot on the deep ligament) are then brought up within the intercollicular groove to a distal-medial tibia screw to create a similar anchor-to-post reinforcement.</td>
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<tr>
<td>Yu et al\textsuperscript{29}</td>
<td>2015</td>
<td>One or two suture anchors in the medial malleolus are used to reattach the superficial deltoid fibers to their anatomic origin. If the deep ligament is avulsed from its insertion on the talus, two anchors are placed in the medial aspect of the talus and attached to the deep deltoid ligament.</td>
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<tr>
<td>Luckino and Hardy\textsuperscript{30}</td>
<td>2015</td>
<td>One suture anchor is placed in the medial talus, and the associated suture is run up within the medial gutter and from deep to superficial through an oblique drill hole in the medial malleolus. The sutures are secured to a suture button on the superficial aspect of the medial malleolus, creating an anchor-to-button reinforcement against talar tilt. No specific suture repair of the deltoid ligament itself was described.</td>
</tr>
<tr>
<td>Hsu et al\textsuperscript{27}</td>
<td>2015</td>
<td>One or two suture anchors are placed in the medial malleolus and used to reattach the superficial deltoid fibers to their anatomic origin.</td>
</tr>
<tr>
<td>Woo et al\textsuperscript{12}</td>
<td>2017</td>
<td>One or two suture anchors are placed on the medial malleolus nearest to the rupture site. If the superficial and deep ligaments are both avulsed from the medial malleolus, an anterior suture anchor is placed for the superficial deltoid and a posterior suture anchor is placed for the deep deltoid. If the deep deltoid is avulsed from the talus, one or two suture anchors are placed into the medial aspect of the talus and used to reattach the deep deltoid.</td>
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\textsuperscript{a} The studies by Stromsoe et al\textsuperscript{31} and Baird and Jackson\textsuperscript{19} are not included in this table because the authors did not describe their technique for deltoid repair.
visualization. At this point, horizontal rents in the superficial deltoid ligament, joint capsule, and/or deep deltoid ligament can often be visualized. The posterior tibial tendon is identified and retracted posteriorly and inferiorly. The talus and medial tibia are often visible through the rent and are inspected for traumatic osteochondral lesions. If sizable lesions are identified, they are treated with microfracture using a Kirschner wire. Of note, although a Kirschner wire may be used (traditional Pridie drilling), a dedicated microfracture awl is an alternative (more current technique). The advantage is of the awl technique is that the small diameter wire may heat the bone, which will not occur with the microfracture awl.

In cases of deltoid avulsion from the medial malleolus (most common), attention is turned to preparing the medial malleolus for repair. The distal tip of the medial malleolus is identified, and a scalpel is used to elevate 1 cm of tissue proximally. A drill hole of appropriate size is created in the medial malleolus for placement of the desired suture anchor(s) (Figure 3, A). One or two suture anchors are placed for fixation of two or four sets of braided nonabsorbable suture (Figure 3, B). Once the anchor(s) is secured within bone, the capsule, deep deltoid, and superficial deltoid are imbricated and reduced to the medial malleolus in a "vest-over-pants" technique (Figure 3, C and D). Suture is used to directly repair the capsular disruption as well. The ankle is then gently stressed in external rotation and eversion to confirm adequate stability.

Although much less common, it is also worth discussing distal avulsion of the deep deltoid from the talus. In these circumstances, it is recommended to use the technique described by Yu et al\textsuperscript{29} for repair. In this technique, the exposure is extended distally using the same interval, but taking increased care not to injure the posterior tibial tendon, posterior tibial artery, and tibial nerve. Two anchors are placed on the medial aspect of the talus at the sites of insertion of the deep anterior and deep posterior tibiotalar ligaments (Figure 1, B). These anchors are sutured to the deep anterior and deep posterior tibiotalar ligaments, respectively. Depending on the location of rupture of the superficial deltoid, that structure is repaired by either direct suture repair (if midsubstance) or a single suture anchor into the fibula (if a fibular avulsion).

### Outcomes

#### Studies Suggesting Adequate Results Without Deltoid Repair

A number of retrospective studies (published mostly during the 1980s) introduced the idea that ORIF of bimalleolar equivalent ankle fractures without deltoid repair has acceptable...
<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Level of Evidence</th>
<th>Number Repaired/ Not Repaired</th>
<th>Mean Follow-up (mo)</th>
<th>Main Result</th>
<th>Conclusion</th>
<th>Limitations</th>
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<tr>
<td>Baird and Jackson</td>
<td>1987</td>
<td>IV (case series, included patients with and without deltoid repair but did not statistically compare groups)</td>
<td>3/21</td>
<td>36</td>
<td>90% of patients in the no repair group had good or excellent results. Patients in the repair group reportedly did not do as well, but the sample size reportedly was not sufficient to statistically compare the nonrepaired and repaired groups.</td>
<td>Exploration of the medial side of the ankle and repair of the deltoid ligament are not necessary unless lateral malleolar reduction fails to close the medial clear space.</td>
<td>Only three patients in deltoid repair group; no statistical comparison; no postoperative stress testing.</td>
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<tr>
<td>Stromsoe et al</td>
<td>1995</td>
<td>II (lesser quality randomized controlled trial)</td>
<td>25/25</td>
<td>17</td>
<td>No difference between the two groups in terms of working ability, sports activities, pain, swelling, and overall movement. Longer surgical time was reported for the deltoid repair cohort.</td>
<td>Deltoid repair is unnecessary assuming that the talus is reduced to the medial malleolus and the anatomy of the fibula is restored.</td>
<td>No power analysis; no postoperative stress testing; no subjective assessment of medial instability.</td>
</tr>
<tr>
<td>Maynou et al</td>
<td>1997</td>
<td>III (retrospective comparative study)</td>
<td>18/17</td>
<td>56</td>
<td>Subjective and objective assessments did not differ between the groups. Medial instability (defined using a system of static and stress radiographs at final follow-up) was observed in four patients (ie, two in the repair group and two in the nonrepair group). Radiographically, one posttraumatic osteoarthritis developed in the nonrepair group and none in the repair group.</td>
<td>Repair of the deltoid ligament is unnecessary if fibular reduction reconstitutes the mortise. Exploration of the medial side is indicated only when fibular reduction fails to close the medial clear space.</td>
<td>No power analysis.</td>
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(continued)
Deltoid Ligament Rupture in Ankle Fracture

Table 2 (continued)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Level of Evidence</th>
<th>Number Repaired/Not Repaired</th>
<th>Mean Follow-up (mo)</th>
<th>Main Result</th>
<th>Conclusion</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woo et al</td>
<td>2018</td>
<td>III (retrospective comparative study)</td>
<td>41/37</td>
<td>17</td>
<td>Final follow-up medial clear space on gravity stress examination was smaller in patients managed with deltoid repair, although clinical outcomes were similar. However, when restricted only to patients who also underwent syndesmotic repair, medial clear space was smaller, and clinical outcomes were superior in the deltoid repair group.</td>
<td>Radiographic medial stability is improved with deltoid ligament repair. No clinical benefit is realized for those patients without syndesmotic injury; however, for patients requiring syndesmotic repair, supplementing with deltoid repair results in improvements in patient-reported outcomes. Hence, deltoid repair may be beneficial in patients with concurrent syndesmotic injury.</td>
<td>Clinical significance of medial clear space widening on postoperative stress view is uncertain.</td>
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</table>

long-term results. The theory behind these studies is that by reapproximating the deltoid tissue through anatomic reconstitution of the mortise (through fibular and syndesmotic ORIF), the deltoid should have the opportunity to scar in and heal into a functional ligament without direct repair. In a good example of one of these early studies, Zeegers and van der Werken retrospectively studied 28 lateral malleolar fractures that were associated with ruptures of the deltoid ligament that all received lateral malleolar ORIF without exploration or repair of the deltoid ligament. After an average of 18 months, no patient had medial laxity either clinically or on eversion stress testing. However, early signs of osteoarthritis were seen in seven patients, five of whom were noted to have had anatomic restoration of the mortise at the time of surgical treatment. Because all but one of the osteoarthritic patients was asymptomatic at final follow-up, the authors concluded that there is no need to explore or repair a ruptured deltoid in an ankle that has been anatomically reduced.

Later studies suggesting adequate results without deltoid repair were improved in design in that they were more commonly comparative studies (Table 2). For example, Maynou et al retrospectively studied 35 patients with bimalleolar equivalent ankle fractures whose surgical treatment did include (n = 18) or did not include (n = 17) deltoid repair. Subjective and objective assessments did not differ between the groups. Medial instability (defined using a system of static and stress radiographs at final follow-up) was observed in two patients in each group. Radiographically, one patient developed posttraumatic osteoarthritis—this was in the nonrepair group. On the basis of these findings, the authors concluded that they could not support deltoid ligament repair in cases in which fibular reduction and fixation achieves an anatomic reconstitution of the mortise.

The first and only randomized study that analyzed the utility of deltoid repair in ankle fractures was conducted in 1995 by Stromsoe et al. These authors randomized 50 patients with Weber B and C fractures and a ruptured deltoid ligament to receive ORIF either with (n = 25) or without (n = 25) repair of the deltoid. At mean 17-month follow-up, the authors found no difference in terms of working ability, sports activities, pain, swelling, and movement. The only difference
they reported was longer surgical time for the deltoid repair cohort. The authors concluded that deltoid repair was unnecessary assuming that the talus was reduced to the medial malleolus and the anatomy of the fibula was restored. However, the reader should note that no power analysis was reported and no assessment of medial instability (either subjective or objective) was performed.

**Studies Suggesting Superior Outcomes With Deltoid Repair**

Although most patients in the studies mentioned earlier did well without deltoid repair, there have been published and anecdotal reports of subpopulations of patients that had less than optimal outcomes. These included reports of medial instability, persistent medial gutter pain, and loss of function with early development of posttraumatic arthritis. The concern is that these outcomes were related to failure of the deltoid ligament to heal in an anatomic position. It is in this setting that a number of orthopaedic foot and ankle surgeons have been performing primary deltoid repair in subsets of patients with bimalleolar equivalent ankle fractures.

Several published studies support deltoid repair. Yu et al studied 106 patients with distal fibular fractures associated with deltoid ligament ruptures that underwent deltoid repair as part of the primary ORIF. At an average of 27 months, clinical outcomes were acceptable, postoperative stress radiographs were all negative, and no cases of posttraumatic arthritis were seen.

Hsu et al reported their experience repairing the deltoid in 14 National Football League players with bimalleolar equivalent ankle fractures. All patients underwent ankle arthroscopy and débridement as a first step to confirm deltoid ligament rupture. After arthroscopy, patients with confirmed deltoid rupture underwent fibular ORIF, syndesmotic fixation, and open deltoid repair. Eighty-six percent of players returned to play, and no players reported of medial pain or instability at final follow-up.

Finally, Woo et al retrospectively evaluated 78 consecutive cases of ORIF of bimalleolar equivalent ankle fracture over a 15-year period. The authors changed their clinical practice half way through this period; patients in the early group (2001–2008, n = 37) were managed without deltoid repair, whereas patients in the late group (2009–2016, n = 41) were managed with deltoid repair. Interestingly, the authors found that the gravity stress view medial clear space at final follow-up was significantly smaller in patients managed with deltoid repair (3.2 ± 0.5 versus 3.7 ± 0.6 mm; P < 0.001). Clinical outcomes were similar between the groups. The authors conducted a post hoc subgroup analysis in which they included only patients who also had syndesmotic injury detected intraoperatively and consequently had undergone syndesmotic fixation (27 in the deltoid repair group and 17 in the no deltoid repair group). In this subgroup analysis, clinical outcomes including the AOFAS score, VAS pain score, and medial-sided pain were all superior in the deltoid repair group. These results suggest that deltoid repair may be clinically beneficial in patients who not only have deltoid rupture but also have syndesmotic injury for which they are undergoing syndesmotic repair. That is, the two repairs may work in concert to reinforce each other and facilitate healing in these patients.

**Future Work**

The field of orthopaedic foot and ankle surgery is lacking a well-powered, rigorous, randomized, controlled trial evaluating the utility of deltoid repair in bimalleolar equivalent ankle fractures. This review uncovered only one randomized study attempting to address this subject. That study included only 25 patients in each group, lacked a description of statistical power, had minimum follow-up of only 5 months, and lacked any form of assessment of medial instability. The ideal study would be powered to detect a difference both in patient-reported outcomes and in medial clear space widening on stress views, would have follow-up of at least 2 years (to evaluate for early development of posttraumatic arthritis), and would carefully exclude or stratify on the basis of syndesmotic injury to minimize the impact of confounding. Such a study would enable a more conclusive answer to this set of controversial questions.

**Summary**

Manual or gravity external rotation stress radiography is the benchmark to differentiate isolated lateral malleolar fractures from bimalleolar equivalent fractures of the ankle. If the medial clear space widens on stress radiography, the patient is
Deltoid Ligament Rupture in Ankle Fracture


References

References printed in bold type are those published within the past 5 years.


